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and 147. Twins are probably distinguishable by their handwriting oftener than by their physical appearance; for I am confident that the bodies of at least five and probably more of these 72 twins would have been as hard to tell apart from a minute's visual inspection as specimens 145 and 147. Of people in general this would probably not hold true, but the distinguishing value of a specimen of natural writing is very high even for them.

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ALLELOMORPHS AND MICE

IN the February number of this journal, C. C. Little points out that Cuénot (1903) recognized certain factors in mice as allelomorphic,[1] and that in my paper of 1914 I not only failed to mention that Cuénot had treated these factors in this way, but that I claimed to have brought forward for the first time a demonstration of the allelomorphism in question. In fact, I did overlook or had forgotten that Cuénot interpreted these types in this way; and curiously enough, my work was undertaken because Little on the alleged results of some of his own earlier experiments denied that the factors for yellow and gray are completely linked, despite Cuénot's evidence, then published, which Little now says established from the ratios obtained that the factors in question are allelomorphic.[2] Little wrote as late as 1913:

> "Yellow" in mice is no more allelomorphic to gray than is gray allelomorphic to black.

If this is the conclusion at which he arrived after his elaborate series of experiments and after Cuénot's work had been done, the need of further work would seem to be obvious.

The failure of several of us to fully appreciate the significance of Cuénot's statements and evidence in regard to allelomorphism may in part be due to the fact that in his second paper Cuénot had used the symbols G (gray) and N (black) as allelomorphs, and had besides used the symbols A (albino) and G (gray) as allelomorphs without, however, intending to mean that there was here a set of three allelomorphs, but using G in each of the two cases to represent a different factor of the gray mouse.[3] This method is in itself quite legitimate, but as a result when Cuénot later spoke of the factor for gray, gray white belly, yellow, and black, all as allelomorphic, some of us, it appears, failed to appreciate that in doing so Cuénot was treating this set of terms in an entirely different way from the way in which he treated the other cases, where he had represented factors as allelomorphic to each other. In the second place, the full significance of multiple allelomorphs in mice was not, I think, fully appreciated until its relation to complete linkage became apparent, and in fact even now this relation is not sufficiently understood by many geneticists themselves. Even, however, had I taken fully into account all that Cuénot had done, the somewhat extensive experiments that I undertook in order to *prove* that the factors in question are allelomorphic would have seemed to me necessary, as they still do, to establish that this series of factors bears this relation to each other. Let us examine, therefore, the evidence, which, according to Mr. Little, rendered my experiments a work of supererogation.

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[1] Note 1903, *Archiv. Zool. Exp. et Gen.* (4), I.

[2] The numerical results are the same for complete linkage and for multiple allelomorphs. The evidence that would disprove the one would also disprove the other.

1. Little says:

> As early as 1903 Cuénot recognized that albinos, potentially yellows, when crossed with black gave besides yellow offspring *either* black or agouti young but not both. This is, of course, evidence that yellow, agouti and black[4] are all allelomorphic to one another.

But the evidence proves nothing of the sort, unless Cuénot had shown that his albinos should have been expected from their history to contain all three factors in question. However likely it may seem, to one so inclined, that such triple forms must sooner or later have been met with by chance, the fact remains that Cuénot had, as the offspring showed, used only double types, and such a fact in the absence of explicit evidence as to the history of the forms used can not be said to *demonstrate* anything in particular.

2. Little continues:

> At the same time he gives the ratios produced by crossing an albino

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[3] The "examples" given on page vii of the second memoir are also instructive in the present case.

[4] Probably Little means here by "black" what he later calls the non-agouti factor. If so he refers to a different factor from that which he called black, when, in 1913, he wrote:—"Black . . . is, moreover, clearly a positive character which is dominant over its absence."

potentially a *heterozygous gray* (agouti) with a yellow carrying black but no agouti and albinism. . . . Cuénot recognized that the ratio expected from the cross was 2 yellow, 1 black and 1 agouti (gray).

If one turns to Cuénot's experiment[5] he finds that Cuénot crossed an albino carrying black (AN) to an albino carrying gray (AG) in order to obtain a "dozen" white mice with the formula AGAN, and similarly he crossed a black mouse (CN) to a white mouse carrying yellow (AJ) in order to obtain another "dozen" mice with the formula CNAJ. We are not told whether each dozen came from the same parents, or from several similar combinations. It will be observed that the yellow (J) and black (N) were brought together to make one F_1, and that gray and black were brought together to make the other F_1, hence since gray was in one F_1 and yellow in the other F_1 it is not possible to tell whether they behave as allelomorphs to each other. There is no reason, then, for making gray and yellow both allelomorphic to the same factor (N), black; for, in the first cross the gametes (omitting A and C) might have been Gj (gray) and gj (black) and in the other cross gJ (yellow) and gj (black). The numerical results would then be those obtained by Cuénot, which would prove nothing in regard to the allelomorphism of gray, yellow and black. In other words, the letter N stands in this cross simply as a symbol for anything in the black mouse that could be treated as allelomorphic to G in the one case, and to J in the other; just as at first when rose comb in fowls was found to give a 3 to 1 ratio with single comb it was treated as an allelomorph to single; and likewise when pea was found to give 3 to 1 with single it too was regarded as allelomorphic to single. Later it was found that S (single) stood for two factors ("absences"), small r and small p.

3. Little thinks that both Cuénot and I have fallen into the same error in regard to black; but he fails to see that from our points of view in regard to the other colors it was inevitable that we should come independently to the same conclusion. Little says that the "true" series of allelomorphs is yellow, white-bellied gray, gray-bellied gray, and non-agouti (not "black"). The factor that Little prefers to call non-agouti, I call the black factor. He regards a non-factor as a member of an allelomorphic series, while I regard the black mouse as the result of the action of a factor for black. By the same criterion as that by which Little speaks of a non-agouti factor, he might equally well claim

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[5] Third note, p. xlix.

that the "true" series is black, gray gray belly, gray white belly and non-agouti (instead of yellow).

The race of white-bellied mice that I have kept for several years does not correspond in all respects to Cuénot's description of those that he has studied. His account of them in 1908[6] is as follows:

> La Souris reste grise sur le dos, mais le ventre prend une teinte blanc roussatre, avec un bouquet de poils plus roux entre les deux pattes de devant, et une bordure un peu plus rousse sur les flancs; elle resemble d'une façon frappante à Mus sylvaticus, L.

Again in 1911[7] Cuénot says:

> La première diffère de la Souris grise sauvage par la teinte du ventre, qui, au lieu d'être gris-clair, est blanc roussâtre, avec un bouquet de poils roux entre les deux pattes de devant et une bordure un peu plus rousse sur les flancs; cette Souris a souvent de gros yeux saillants, de sorte qu'elle ressemble d'une façon frappante au Mulot (Mus sylvaticus, L.).

In my race of white-bellied mice there is not a bouquet of russet hairs between the front legs, and I have not observed that the eyes are large and protruding more than occurs at times in other mice. At present, however, I have two old mice that were recently found that have a tuft of faint russet hairs between the forelegs. Whether we have here still another allelomorph, or whether a particular genetic constitution makes apparent the bouquet in conjunction with the white-bellied factor, remains to be worked out. While it seems probable that Cuénot's type of white-bellied mouse and that which I have studied are the same, it is not *certain* that such is the case until further work has been done.

Cuénot has not published as yet any conclusive evidence to show that the gray mice with white belly belong to the series of allelomorphs, although it is true he states that this type is allelomorphic to the three other types. Finally, I should like to add that I am far from wishing to appear to minimize the importance of Cuénot's work, and it is now evident that he should have received full credit for his recognition of the allelomorphic nature of the four factors in question. I still think, nevertheless, that there was room, as matters stood, for the analysis that Sturtevant published and for the work that I carried out.[8]

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[6] Sixth note, II, p. xv.

[7] Seventh note, p. xlvii.

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A METHOD OF CALCULATING THE PERCENTAGE OF RECESSIVES FROM INCOMPLETE DATA

IN the very interesting article on "The Inheritance of Left-handedness" by Professor Ramaley in the December number of the NATURALIST, a table is given on page 736 showing the proportion of right- and left-handed children in families where both parents are presumably heterozygous for right- and left-handedness, including only families with left-handed children. In 93 such families there are 282 right-handed and 116 left-handed children.[1] This gives 29.13 per cent. of left-handedness in these families. It is clear, however, that this does not represent the true Mendelian proportions if right-handedness is a simple Mendelian dominant over left-handedness. For instance, in families where both parents are heterozygous and in which there is only one offspring, the probabilities are that only one family in four will show the recessive character. From the total population re-

TOTAL NUMBER OF CHILDREN FROM PARENTS HETEROZYGOUS FOR RIGHT- AND LEFT-HANDEDNESS, BASED ON THE NUMBER OF FAMILIES OMITTED BECAUSE OF ABSENCE OF LEFT-HANDED CHILDREN IN PROF. RAMALEY'S TABLE 4.

Children per Family	Actual Number of Families	Actual Number of Children	Corrected Number of Families	Corrected Number of Children
1	4	4	16	16
2	14	28	32	64
3	17	51	29 4	88.2
4	23	92	33.63	134.5
5	18	90	23.6	118.0
6	5	30	6.08	36.45
7	1	7	1.154	8.08
8	6	48	6.666	53.35
9	4	36	4.325	38.90
12	1	12	1.032	12.39
		Total................................		569.87

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[8] *Archiv. de Zool. Exp. et Gen.* (4), IX; (5), VIII.

[1] By oversight in Professor Ramaley's additions one column of right-handed children was omitted, so that the numbers given in the table are incorrect.